

Certification Radio test report

According to the standard:

CFR 47 FCC PART 15
RSS GEN – Issue 5
RSS 247 – Issue 2

Equipment under test:
Wireless seismic acquisition unit
AFU

FCC ID: KQ9-0800A
IC NUMBER: 1317A-0800A

Company:
SERCEL Inc

Distribution: Mr TIJOU

(Company: SERCEL NANTES)

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DESIGNATION OF PRODUCT: *Wireless seismic acquisition unit*

Serial number (S/N): Sample 1: 1562674

Reference / model (P/N): AFU

Software version: 0.9.11

MANUFACTURER: SERCEL Inc

COMPANY CERTIFYING THE PRODUCT:

Company: SERCEL Inc

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Responsible: Mr PARRISH

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Responsible: Mr TIJOU

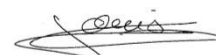
Person(s) present during the tests: Mr ALLAIN (the first day)

DATES OF TEST: From 2-Nov-20 to 4-Nov-20

TESTING LOCATION: EMITECH ANGERS laboratory at JUIGNE SUR LOIRE (49) FRANCE
FCC Accredited under US-EU MRA Designation Number: FR0009
Test Firm Registration Number: 873677
ISED Accredited under CANADA-EU MRA Designation Number: FR0001
Industry Canada Registration Number: 4452A

TESTED BY: S. LOUIS

VISA:



WRITTEN BY: S. LOUIS

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1. INTRODUCTION

This report presents the results of radio test carried out on the following radio equipment: **Wireless seismic acquisition unit, AFU**, in accordance with normative reference.

The equipment under test integrates:

- SRD Multifrequencies proprietary transceiver operational in the band (2400MHz – 2483.5MHz).
Two different modulations are used (GFSK and LoRa).
- GNSS module operational in the band 1559MHz – 1610MHz

This report refers only of proprietary transceiver radio part.

According to KDB publication n° 558074 D01 v05r02, the compliance demonstration for these two modulations is carried out according DTS requirements.

2. PRODUCT DESCRIPTION

Class:	A
Utilization:	Industrial
Antenna type and gain:	2 dBi / integral antenna
Operating frequency band:	From 2400 MHz to 2483.5 MHz
Operating frequency range:	From 2402.5 MHz to 2478.5 MHz
Number of channels:	77
Frequencies tested:	2402.5 MHz, 2439.5 MHz and 2478.5 MHz
Channel spacing:	1MHz
Modulation:	GFSK & LoRa
Power source:	3.6Vdc by internal Li-ion Batteries Pack
Power soft adjusted to	7dBm

Power level, frequency range and channels characteristics are not user adjustable.
The details pictures of the product and the circuit boards are joined with this file.

3. **NORMATIVE REFERENCE**

The standards and testing methods related throughout this report are those listed below.

They are applied on the whole test report even though the extensions (version, date and amendment) are not repeated.

CFR 47 FCC Part 15 (2020)	Radio Frequency Devices
ANSI C63.10	2013 Procedures for Compliance Testing of Unlicensed Wireless Devices.
558074 D01 DTS v05 r02	Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules.
RSP-100	Issue 12, August 2019 Certification of Radio Apparatus
RSS-Gen	Issue 5, April 2018 General Requirements for Compliance of Radio Apparatus
RSS-247	Issue 2, February 2017 Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

4. TEST METHODOLOGY

Radio performance tests procedures given in CFR 47 part 15:

Subpart C – Intentional Radiators

Paragraph 203: Antenna requirement

Paragraph 205: Restricted bands of operation

Paragraph 207: Conducted limits

Paragraph 209: Radiated emission limits; general requirements

Paragraph 215: Additional provisions to the general radiated emission limitations

Paragraph 247: Operation within the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz

Radio performance tests procedures given in RSS-Gen:

Paragraph 2 - General

Paragraph 3 - Normative publications and related documents

Paragraph 4 - Labelling requirements

Paragraph 6 - General administrative and technical requirements

Paragraph 8 - Licence-exempt Radio Apparatus

Radio performance tests procedures given in RSS-247:

Paragraph 3 - Certification requirements

Paragraph 4 - Measurement method

Paragraph 5 - Standard specifications for frequency hopping systems and digital transmission systems operating in the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz

5. TEST EQUIPMENT CALIBRATION DATES

Emitech Number	Model	Type	Last calibration	Calibration interval (years)	Next calibration due
0	BAT-EMC V3.18.0.26	Software	/	/	/
1406	EMCO 6502	Loop antenna	24/04/2020	1	24/04/2021
4087	Filtek LP03/1000-7GH	Low Pass Filter	25/02/2020	3	24/02/2023
4088	R&S FSP40	Spectrum Analyzer	04/05/2020	2	04/05/2022
7124	A.H. Systems SAS-572	Antenna	05/01/2019	3	04/01/2022
7125	A.H. Systems SAS-572	Antenna	05/01/2019	3	04/01/2022
7279	SUCOFLEX SF104 N 1.5m	Cable	11/06/2020	2	11/06/2022
7299	Microtronics BRM50702	Reject band filter	04/09/2019	3	03/09/2022
8511	HP 8447D	Low-noise amplifier	25/02/2020	1	24/02/2021
8526	Schwarzbeck VHBB 9124	Biconical antenna	17/08/2018	3	16/08/2021
8535	EMCO 3115	Antenna	28/04/2020	3	28/04/2023
8543	Schwarzbeck UHALP 9108A	Log periodic antenna	17/08/2018	3	16/08/2021
8593	SIDT Cage 2	Anechoic chamber	/	/	/
8704	LUCIX Corp S180265L3201 LNA	Low-noise amplifier	08/09/2020	1	08/09/2021
8750	La Crosse Technology WS-9232	Meteo station	22/09/2020	2	22/09/2022
8896	ACQUISYS GPS8	Satellite synchronized frequency standard	/	/	/
8974	STORM MICROWAE k-20cm	cable	14/11/2019	2	13/11/2021
8975	STORM MICROWAE k-20cm	cable	14/11/2019	2	13/11/2021
12911	Huber + Suhner N-2m	cable	11/06/2020	2	11/06/2022
14736	MATURO	Turntable and mat controller MCU	/	/	/
14831	Fluke 177	Multimeter	25/02/2020	2	24/02/2022
15812	COMP-POWER PAM- 118A	Low-noise amplifier 18GHz	05/08/2020	1	05/08/2021
15882	SUCOFLEX	cable N 5m	28/11/2018	2	27/11/2020

(1) The equipment is not verified; instead, the output voltage is checked before each measurement with the calibrated multimeter.

6. TESTS RESULTS SUMMARY

6.1 CFR 47 part 15 requirements

Test procedure	Description of test	Respected criteria?				Comment
		Yes	No	NAP	NAs	
FCC Part 15.203	ANTENNA REQUIREMENT	X				Note 1
FCC Part 15.205	RESTRICTED BANDS OF OPERATION	X				
FCC Part 15.207	CONDUCTED LIMITS			X		Supplied by batteries
FCC Part 15.209	RADIATED EMISSION LIMITS; general requirements	X				Note 2
FCC part 15.215	ADDITIONAL PROVISIONS TO THE GENERAL RADIATED EMISSION LIMITATIONS					
	(a) Alternative to general radiated emission limits	X				
	(b) Unwanted emissions outside of §15.247 frequency bands	X				Note 3
	(c) 20 dB bandwidth and band-edge compliance	X				
FCC Part 15.247	OPERATION WITHIN THE BANDS 902-928 MHZ, 2400-2483.5 MHz and 5725-5850 MHz					
	(a) (1) Hopping systems			X		
	(a) (2) Digital modulation techniques	X				Note 4
	(b) Maximum peak output power	X				Note 5
	(c) Operation with directional antenna gains > 6 dBi			X		
	(d) Intentional radiator	X				
	(e) Peak power spectral density	X				
	(f) Hybrid system			X		
	(g) Frequency hopping requirements			X		
	(h) Frequency hopping intelligence			X		
	(i) RF exposure compliance	X				

NAP: Not Applicable

NAs: Not Asked

Note 1: Integral antenna without standard connector.

Note 2: See FCC part 15.247 (d).

Note 3: See FCC part 15.209. Unwanted emissions levels are all below the fundamental emission field strength level.

Note 4: The minimum 6 dB bandwidth of the equipment is 670 kHz for GFSK Modulation and 546 kHz for LoRa Modulation.

Note 5: Conducted measurement is not possible (integral antenna), so we used the radiated method in anechoic room.

6.2 RSS-Gen requirements

Test procedure	Description of test	Criteria respected ?				Comment
		Yes	No	NAp	NAs	
Paragraph 8	Licence-exempt radio apparatus					
§ 8.1	Measurement Bandwidths and Detector Functions	X				
§ 8.2	Pulsed operation	X				
§ 8.3	Prohibition of amplifiers	X				
§ 8.4	User manual notice	X				see certification documents
§ 8.5	Measurement of licence-exempt devices on-site (in-situ)			X		
§ 8.6	Operating frequency range of devices in master/slave networks	X				
§ 8.7	Radio frequency identification (RFID) devices			X		
§ 8.8	AC power line conducted emissions limits			X		Supplied by batteries
§ 8.9	Transmitter emission limits	X				
§ 8.10	Restricted frequency bands	X				
§ 8.11	Frequency stability			X		

NAp: Not Applicable

NAs: Not Asked

6.3 RSS-247 requirements

Test Procedure RSS-247	Description of test	Criteria respected ?				Comment
		Yes	No	NAp	NAs	
Paragraph 5	Standard specifications for frequency hopping system and digital transmission systems operating in the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz					
5.1	Frequency hopping systems (FHS)			X		
5.2	Digital transmission systems	X				Note
5.3	Hybrid systems			X		
5.4	Transmitter output power and equivalent isotropically radiated power (e.i.r.p.) requirements	X				
5.5	Unwanted emissions	X				

NAp: Not Applicable

NAs: Not Asked

Note: The minimum 6 dB bandwidth of the equipment is 670 kHz for GFSK Modulation and 546 kHz for LoRa Modulation.

7. MEASUREMENT UNCERTAINTY

To declare, or not, the compliance with the specifications, it was not explicitly taken into account of uncertainty associated with the result(s)

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for normal distribution corresponds to a coverage probability of approximately 95%.

Parameter	Emitech Uncertainty
RF power, conducted	$\pm 0.75\text{dB}$
Radiated emission valid to 26 GHz	
F < 62.5 MHz:	$\pm 5.14\text{ dB}$
62.5 MHz < F < 1 GHz:	$\pm 5.13\text{ dB}$
1 GHz < F < 26 GHz:	$\pm 5.16\text{ dB}$
AC Power Lines conducted emissions	$\pm 3.38\text{ dB}$
Temperature	$\pm 1\text{ }^{\circ}\text{C}$
Humidity	$\pm 5\text{ \%}$

8. OCCUPIED BANDWIDTH

Temperature (°C) : 20.8 to 21.1

Humidity (%HR): 43 to 67

Date : November 2, 2020 and
November 4, 2020

Technician : S. LOUIS

Standard: FCC Part 15
RSS-247

Test procedure:

Method of paragraphs 11.8 of ANSI C63.10 (6dB Measurement)

Method of paragraphs 6.9.3 of ANSI C63.10 (99% Measurement)

Test set up:

Test realized in near field.

Setting:

Measure	6dB	99%
Center frequency	The centre frequency of the channel under test	
Detector	Peak	
Span	2 to 5 times the OBW	1.5 to 5 times the OBW
RBW	100kHz	1% to 5% of the OBW
VBW	300kHz	3 x RBW
Trace	Max hold	
Sweep	Auto	

Test operating condition of the equipment:

The equipment under test is blocked in continuous modulated transmission mode, at the highest output power level at which the transmitter is intended to operate.

We used for power source the internal battery pack of the equipment and we noted:

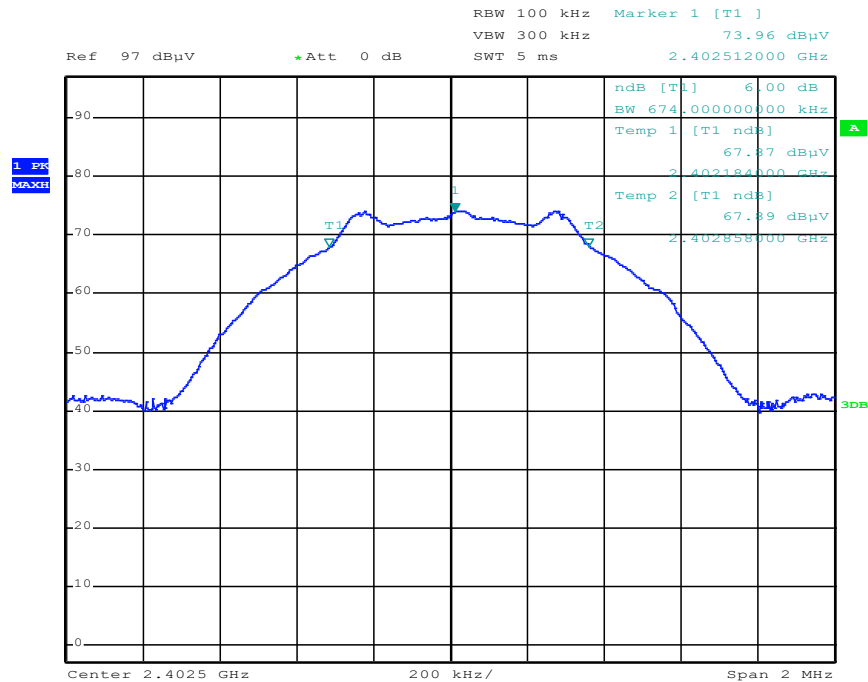
Voltage at the beginning of test (Vdc): 4.08

Voltage at the end of test (Vdc): 4.06

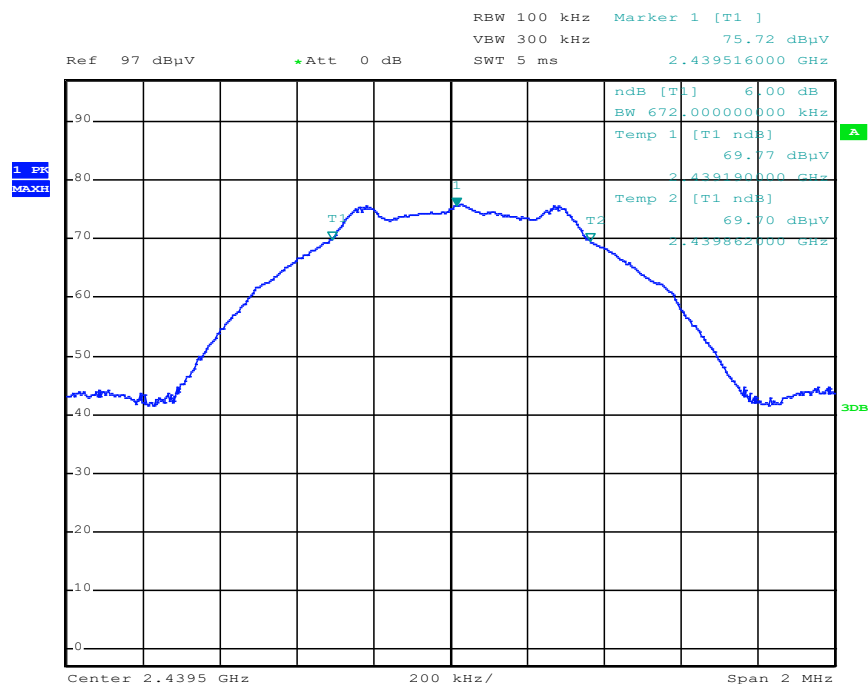
Percentage of voltage drop during the test (%): 0.5

Results: Sample N° 1

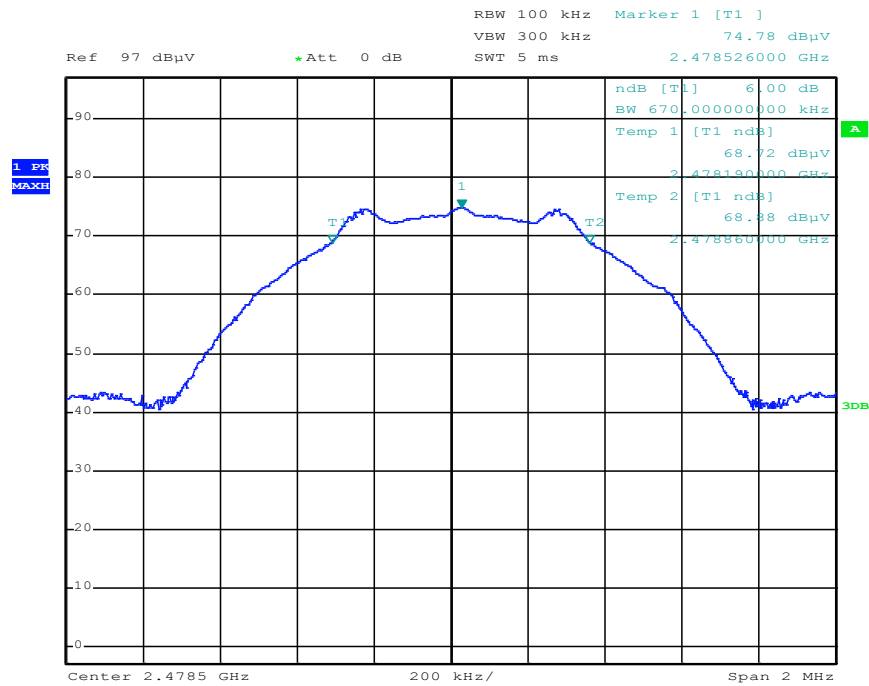
6dB bandwidth – Channel 2402.5 MHz – GFSK Modulation



6dB bandwidth – Channel 2439.5 MHz – GFSK Modulation



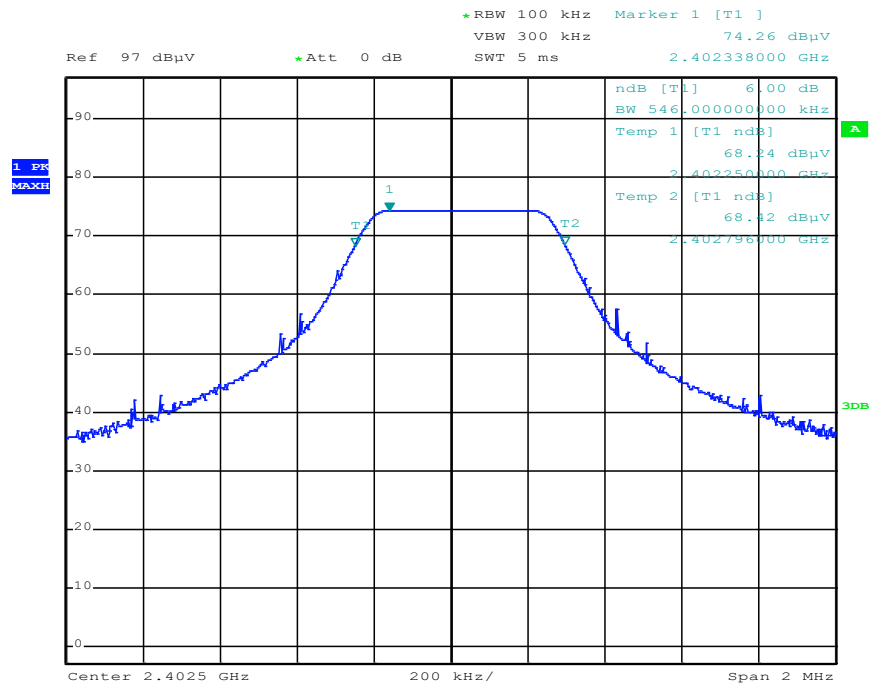
6dB bandwidth – Channel 2478.5 MHz – GFSK Modulation



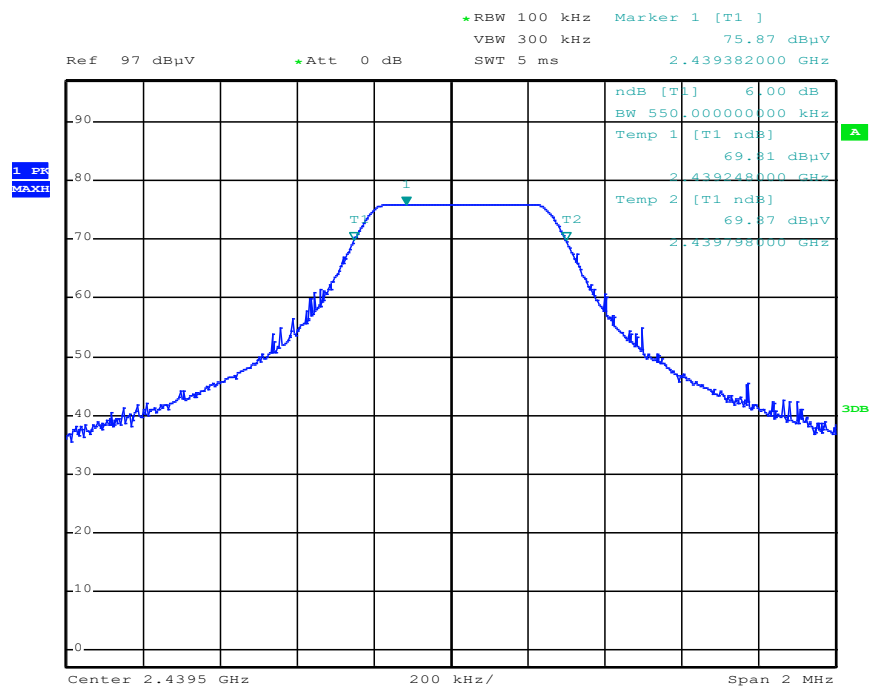
Limit:

Shall be at least 500 kHz

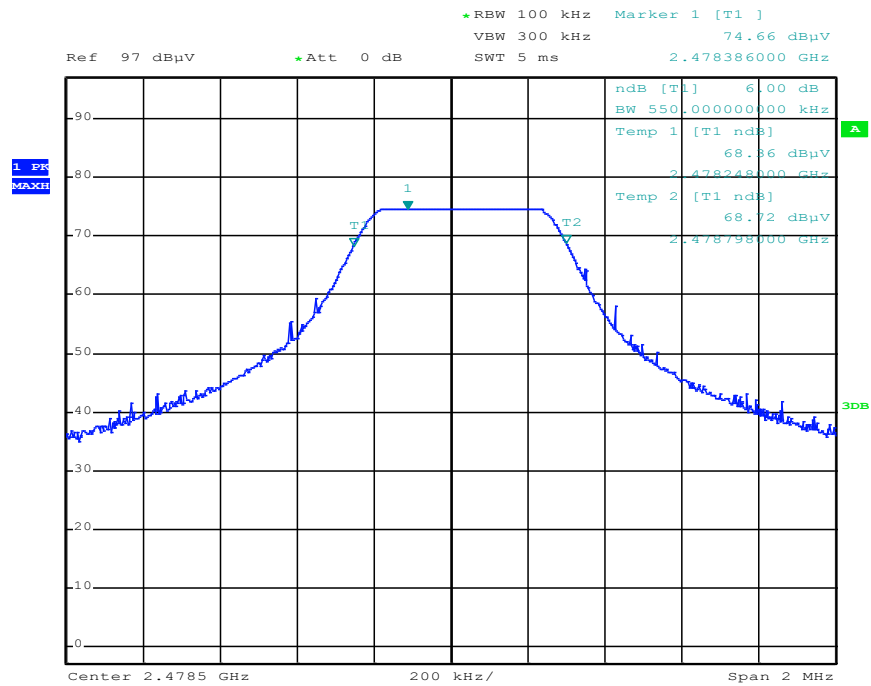
6dB bandwidth – Channel 2402.5 MHz – LoRa Modulation



6dB bandwidth – Channel 2439.5 MHz – LoRa Modulation



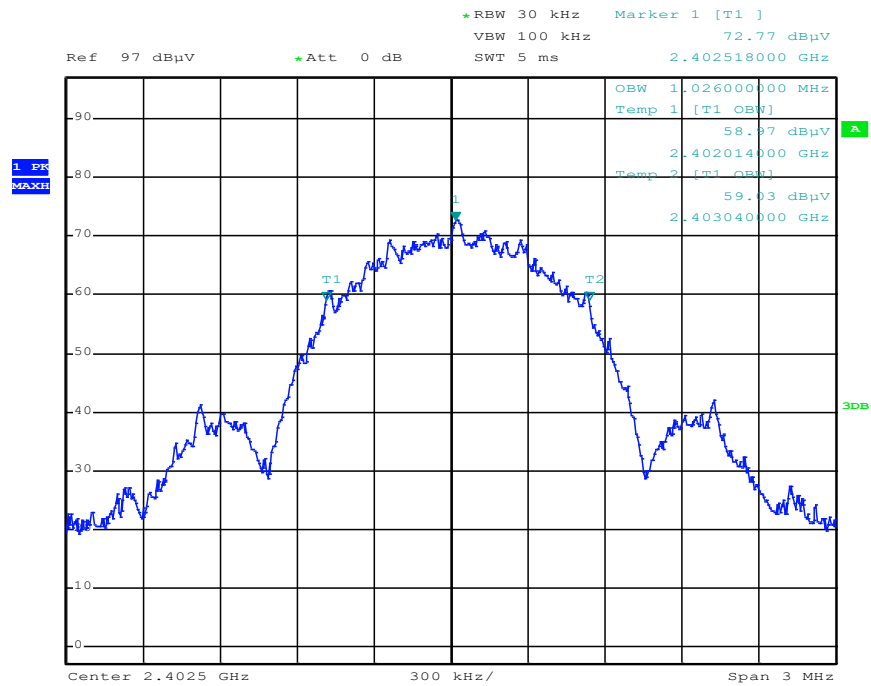
6dB bandwidth – Channel 2478.5 MHz – LoRa Modulation



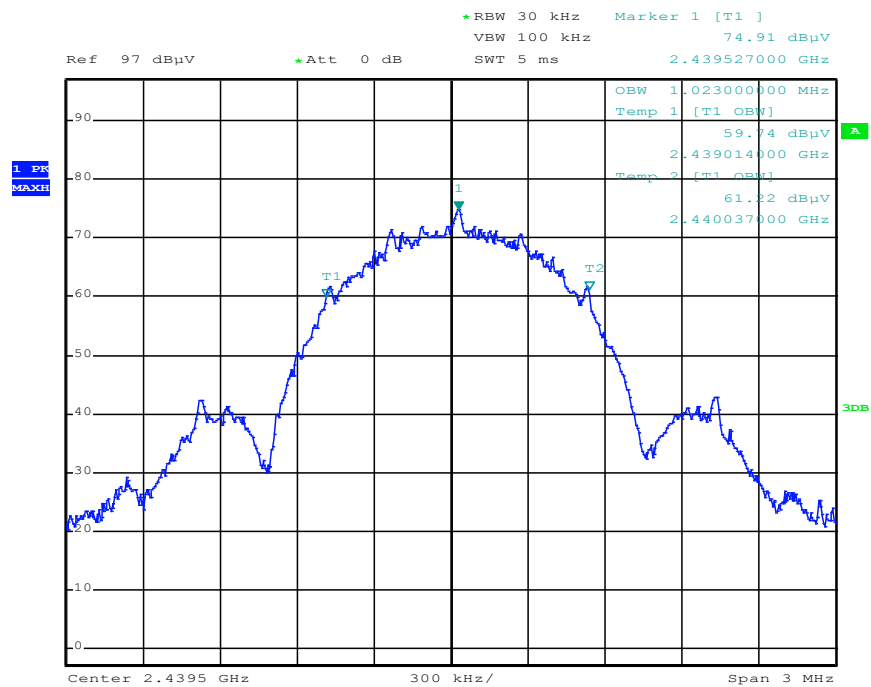
Limit:

Shall be at least 500 kHz

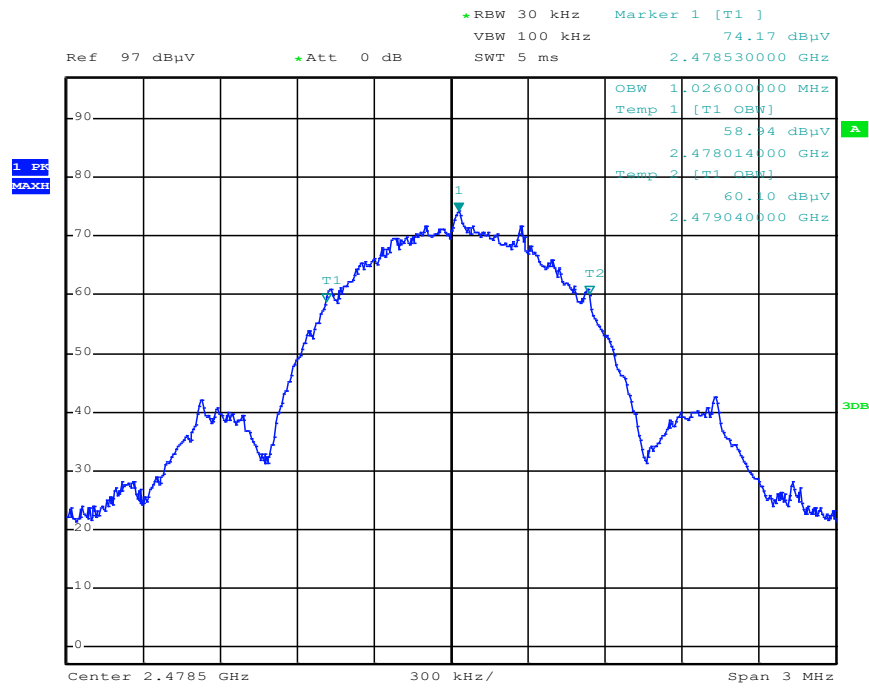
99% bandwidth – Channel 2402.5 MHz – GFSK Modulation



99% bandwidth – Channel 2439.5 MHz – GFSK Modulation

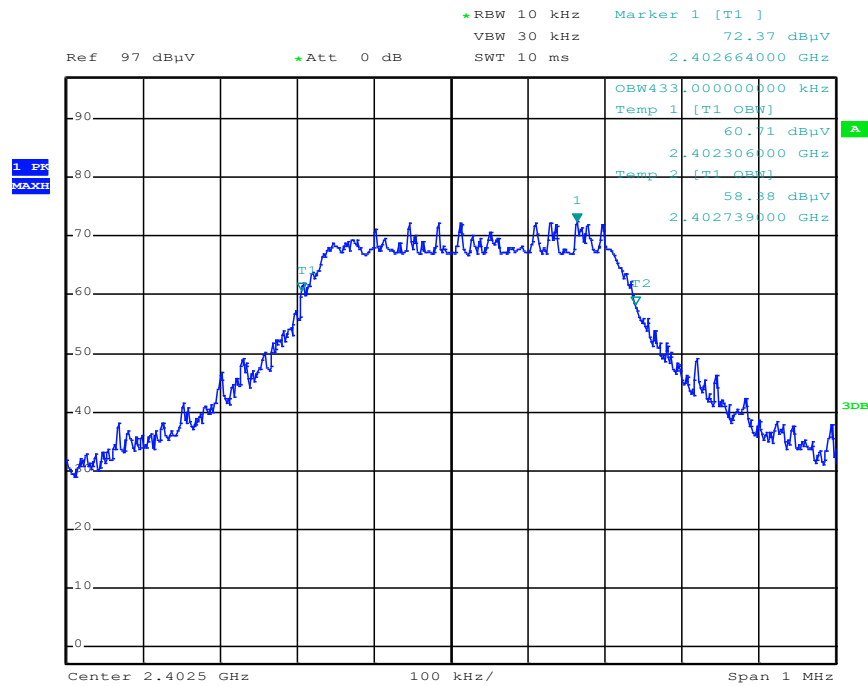


99% bandwidth – Channel 2478.5 MHz – GFSK Modulation

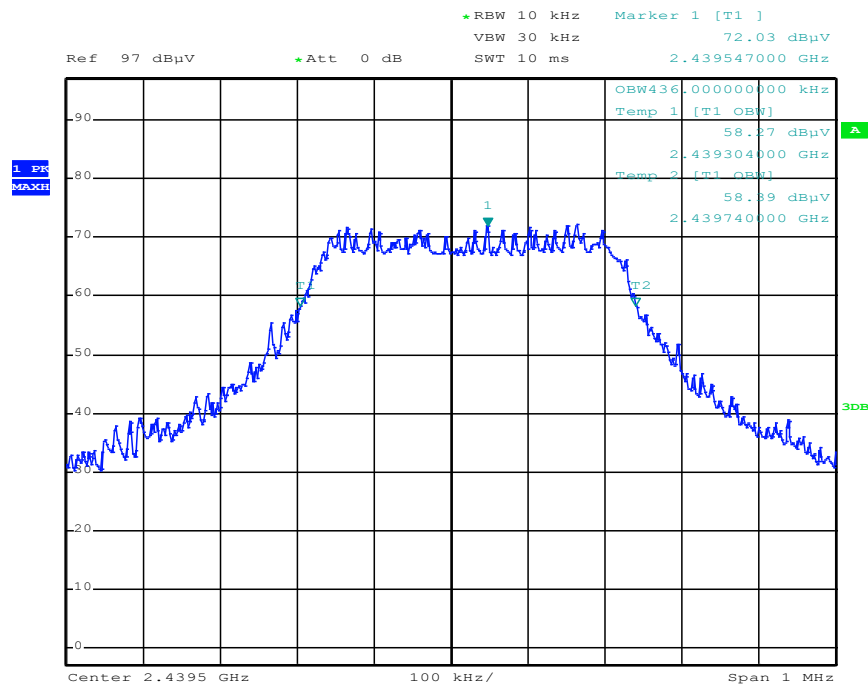


Measure realized for reporting only

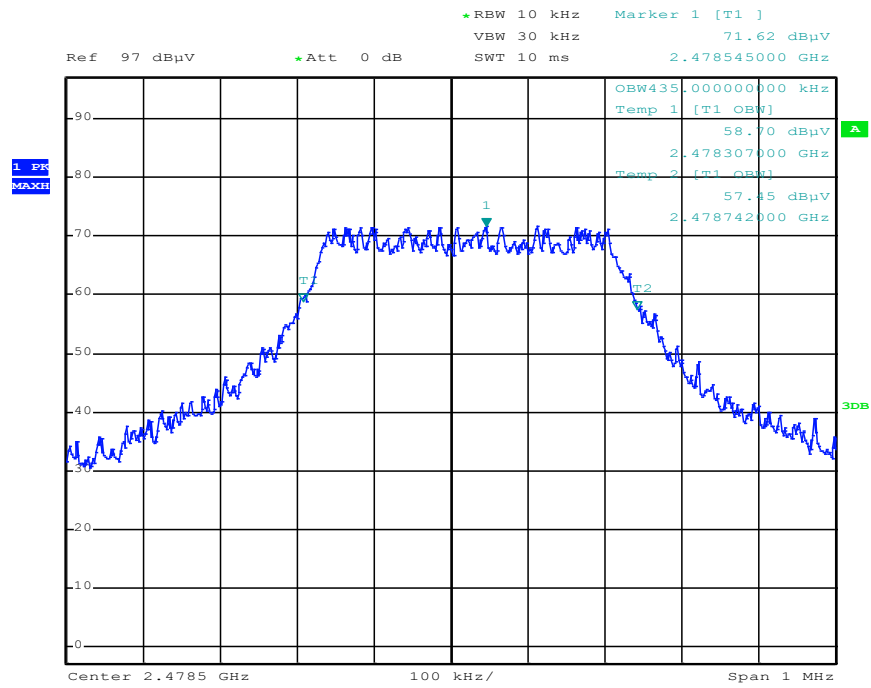
99% bandwidth – Channel 2402.5 MHz – LoRa Modulation



99% bandwidth – Channel 2439.5 MHz – LoRa Modulation



99% bandwidth – Channel 2478.5 MHz – LoRa Modulation



Measure realized for reporting only

9. BAND EDGE**Temperature (°C) :** 21.3**Humidity (%HR):** 48**Date :** November 3, 2020**Technician :** S. LOUIS**Standard:** FCC Part 15
RSS-247**Test procedure:**

Method of paragraph 11.13.3 of ANSI C63.10

Test set up:

Test realized in near field. All field strength measurements are correlated with the radiated maximum peak output power

Test operating condition of the equipment:

The equipment under test is blocked in continuous modulated transmission mode, at the highest output power level at which the transmitter is intended to operate.

P Software adjusted to +7dBm

We used for power source the internal battery pack of the equipment and we noted:

Voltage at the beginning of test (Vdc): 4.08

Voltage at the end of test (Vdc): 4.06

Percentage of voltage drop during the test (%): 0.5

Results:

Lower Band Edge: From 2398 MHz to 2400 MHz

Upper Band Edge: From 2483.5 MHz to 2485.5 MHz

Sample N° 1 : GFSK Modulation

Fundamental frequency (MHz)	Field Strength Level of fundamental (dBμV/m)	Detector (Peak or Average)	Frequency of maximum Band-edges Emission (MHz)	Delta Marker (dB) (1)	Calculated Max Out-of-Band Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2402.5	104.4	Peak	2399.34	52.0	52.4	84.4	32.0
2478.5	104.1	Peak	2483.51	48.5	55.6	74	18.4
2478.5	104.1	Average	2483.51	55.7	48.4	54	5.6

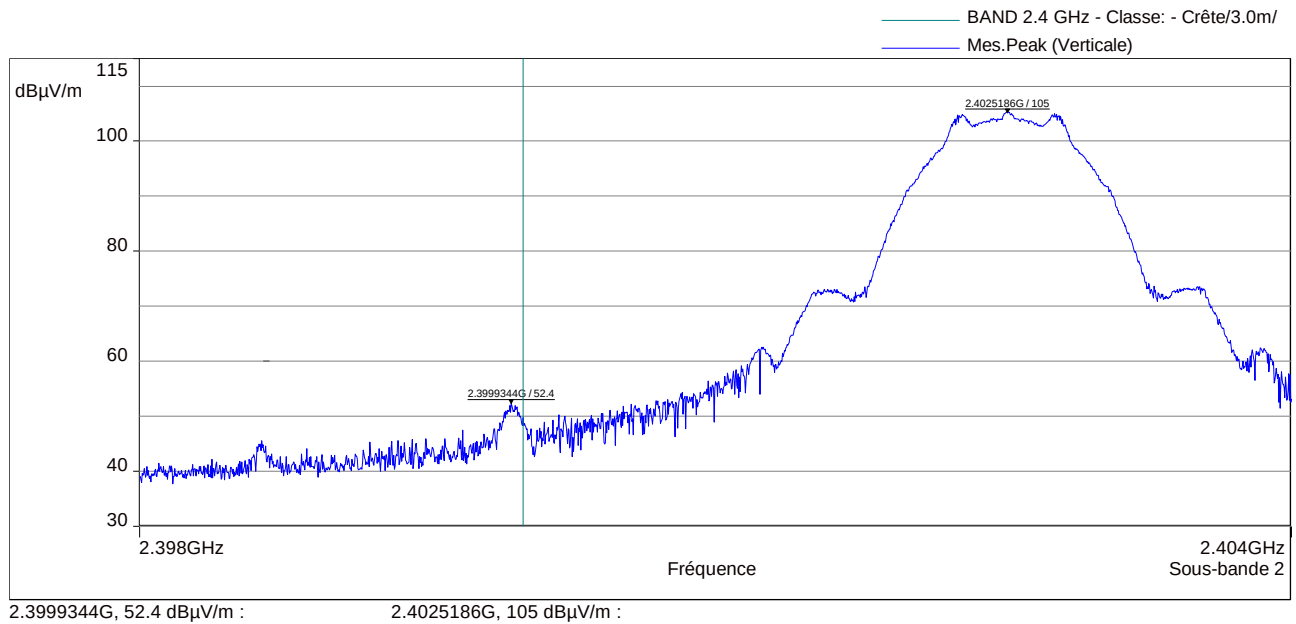
(1) Marker-Delta method

Sample N° 1 : LoRa Modulation

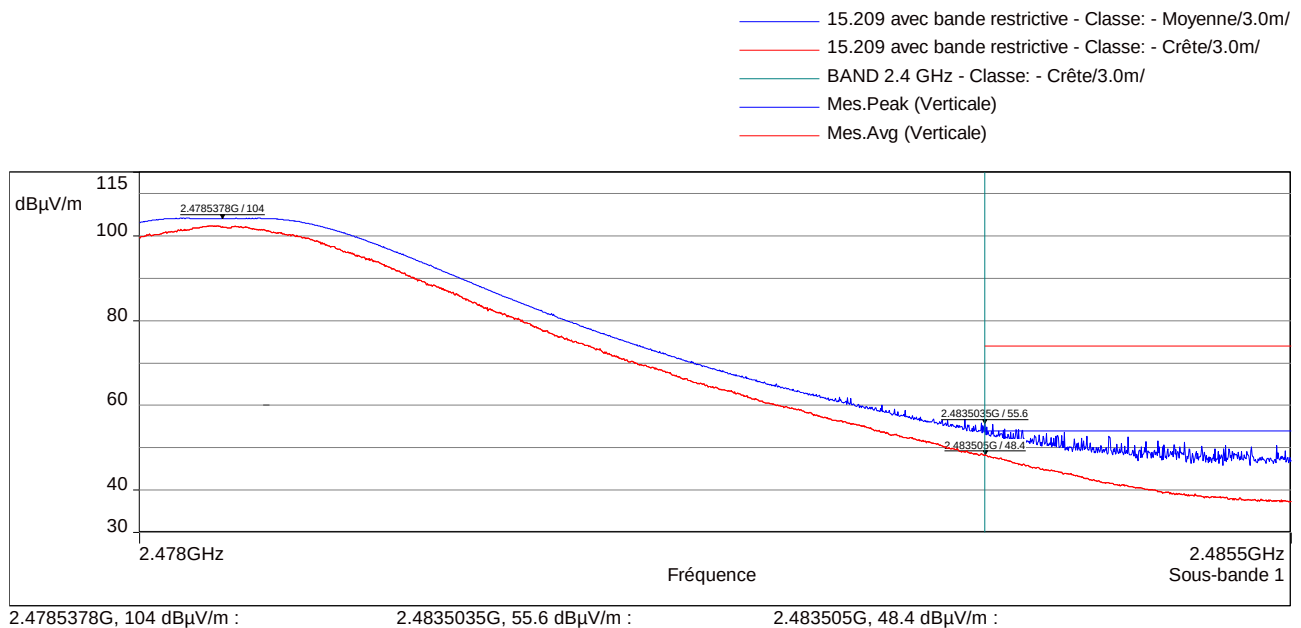
Fundamental frequency (MHz)	Field Strength Level of fundamental (dBμV/m)	Detector (Peak or Average)	Frequency of maximum Band-edges Emission (MHz)	Delta Marker (dB) (1)	Calculated Max Out-of-Band Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2402.5	104.3	Peak	2399.51	53.1	51.2	83.3	32.1
2478.5	104.3	Peak	2483.51	44.1	60.2	74	13.8
2478.5	104.3	Average	2483.51	54.4	49.9	54	4.1

(1) Marker-Delta method

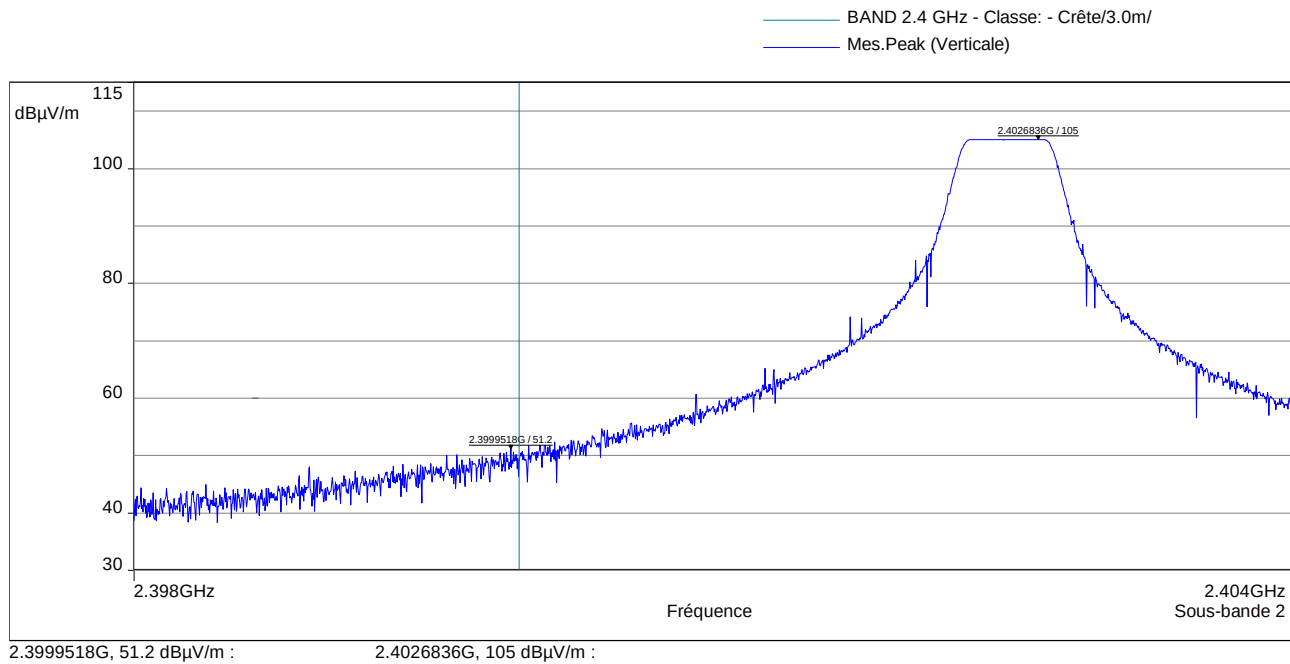
Low Channel – GFSK Modulation: Band edge worst case measurement



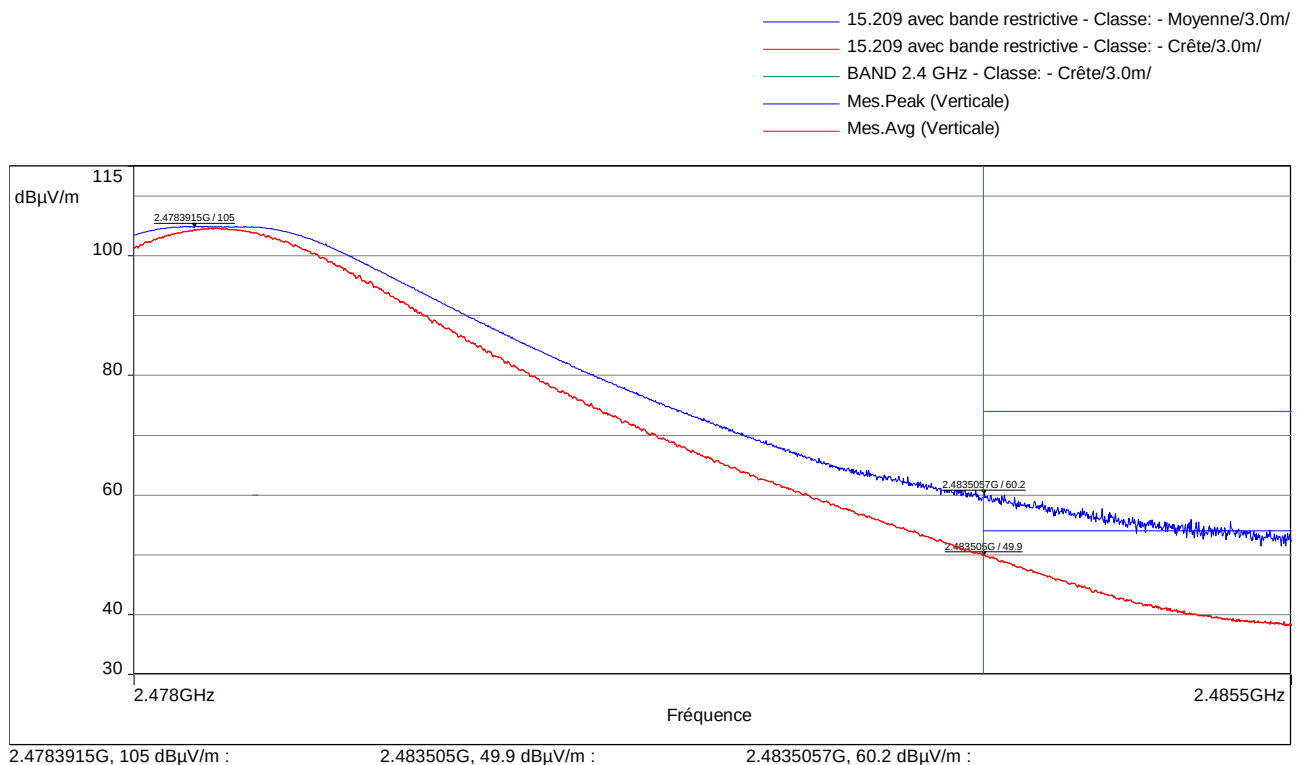
High Channel – GFSK Modulation: Band edge worst case measurement



Low Channel – LoRa Modulation: Band edge worst case measurement



High Channel – LoRa Modulation: Band edge worst case measurement



Test conclusion:

RESPECTED STANDARD

10. PEAK CONDUCTED OUTPUT POWER**Temperature (°C) :** 21.3**Humidity (%HR):** 48**Date :** November 3, 2020**Technician :** S. LOUIS**Standard:** FCC Part 15
RSS-247**Test procedure:**

For FCC Part 15: paragraph 15.247 (b)

For RSS-247: paragraph 5.4

RBW≥DTS bandwidth method of paragraph 11.9.1.1 of ANSI C63.10

Test set up:

First an exploratory radiated measurement was performed.

During this phase the product is oriented in these two normal positions.

Then the final measurement is realized with the product on the most critical orientation.

The system is tested in anechoic chamber, the EUT is placed on a rotating table, 1.5 m from a ground plane.

Zero degree azimuths correspond to the front of the device under test.

See photos in appendix 2.

Distance of antenna: 3 meters**Antenna height:** 1.5 meter**Antenna polarization:** vertical and horizontal (only the highest level is recorded)

The measurement of the radiated electro-magnetic field is realized with an analyser and peak detector. The resolution bandwidth is adjusted at 10 MHz and video bandwidth at 10 MHz. (11.9.1.1 of ANSI C63.10)

Finally the radiated electro-magnetic field is converted in dBm with the following formula:

 $EIRP(dBm) = E (dB\mu V/m) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 2 dBi.**Equipment under test operating condition:**

The equipment is blocked in continuous modulated transmission mode by an internal data signal at the highest power level at which the transmitter is intended to operate.

P Software adjusted to +7dBm

We used for power source the internal battery of the equipment and we noted:

Voltage at the beginning of test (Vdc): 4.06

Voltage at the end of test (Vdc): 4.04

Percentage of voltage drop during the test (%): 0.5

Limits (%): ± 5

Results:

Results: GFSK Modulation

Sample N° 1 Low Channel (F = 2402.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted output power		Limit (W)
		(dBm)	(W)	
Nominal supply voltage: 3.6Vdc	104.4	7.17	0.0052	1

Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Sample N° 1 Central Channel (F = 2439.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted output power		Limit (W)
		(dBm)	(W)	
Nominal supply voltage: 3.6Vdc	105.2	7.97	0.0063	1

Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Sample N° 1 High Channel (F = 2478.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted output power		Limit (W)
		(dBm)	(W)	
Nominal supply voltage: 3.6Vdc	104.1	6.87	0.0049	1

Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Maximum Peak conducted output power:

$EIRP(dBm) = E(dBμV/m) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 2 dBi.

Results: LoRa Modulation

Sample N° 1 Low Channel (F = 2402.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted output power		Limit (W)
		(dBm)	(W)	
Nominal supply voltage: 3.6Vdc	104.3	7.07	0.0051	1

Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Sample N° 1 Central Channel (F = 2439.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted output power		Limit (W)
		(dBm)	(W)	
Nominal supply voltage: 3.6Vdc	106	8.77	0.0075	1

Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Sample N° 1 High Channel (F = 2478.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted output power		Limit (W)
		(dBm)	(W)	
Nominal supply voltage: 3.6Vdc	104.3	7.07	0.0051	1

Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Maximum Peak conducted output power:

$EIRP(dBm) = E (dB\mu V/m) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 2 dBi.

Test conclusion:

RESPECTED STANDARD

11. RADIATED SPURIOUS EMISSIONS**Temperature (°C) :** 20.5 to 21.6**Humidity (%HR):** 43 to 67**Date :** November 2, 2020 to
November 4, 2020**Technician :** S. LOUIS**Standard:** FCC Part 15
RSS-247**Test procedure:**

For FCC Part 15: paragraph 15.205, paragraph 15.209, paragraph 15.247 (d)

For RSS-247: paragraph 5.5

Emissions in non-restricted frequency bands method of paragraph 11.11 of ANSI C63.10

Emissions in restricted frequency bands method of paragraph 11.12 of ANSI C63.10

Test set up:

First an exploratory radiated measurement was performed.

During this phase the product is oriented in these two normal positions.

Then the final measurement is realized with the product on the most critical orientation.

The measure is realized on open area test site under 1 GHz and in anechoic chamber above 1 GHz.

When the system is tested in an open area test site (OATS), the EUT is placed on a rotating table, 0.8m from a ground plane.

When the system is tested in anechoic chamber, the EUT is placed on a rotating table, 1.5 m from a ground plane.

Zero degree azimuths correspond to the front of the device under test.

See photos in appendix 2.

Frequency range: From 9 kHz to 26GHz (10th harmonic of the highest fundamental frequency 2478.5MHz)**Detection mode:** Quasi-peak (F < 1 GHz)

Peak / Average (F > 1 GHz)

Bandwidth: 200Hz (9 kHz < F < 150kHz)
9 kHz (150 kHz < F < 30MHz)
120 kHz (30 MHz < F < 1 GHz)
100 kHz / 1 MHz (F > 1 GHz)**Distance of antenna:** 10 meters (in open area test site) / 3 meters (in anechoic room)**Antenna height:** 1 to 4 meters (in open area test site) / 1.5 meter (in anechoic room)**Antenna polarization:** vertical and horizontal (only the highest level is recorded)

Equipment under test operating condition:

The equipment is blocked in continuous modulated transmission mode by an internal data signal at the highest power level at which the transmitter is intended to operate.

P Software adjusted to +7dBm

We used for power source the internal battery of the equipment and we noted:

Voltage at the beginning of test (Vdc): 4.08

Voltage at the end of test (Vdc): 4.05

Percentage of voltage drop during the test (%): 0.73

Limits (%): ± 5

Results:

Results: GFSK Modulation

Sample N° 1 Low Channel (F = 2402.5 MHz)

Frequencies (MHz)	Detector P QP Av	Antenna height (cm)	RBW (kHz)	Position	Polarization H: Horizontal V: Vertical	Field strength Measured at 3 m (dBμV/m)	Limits (dBμV/m) or (dBm)	Margin (dB)
4805 (1)	P	150	1000	1	H	47.5 (2)	74	26.5
7207.5	P	150	100	1	H	59.7	85.2	25.5
9610	P	150	100	1	H	54.3	85.2	30.9

P= Peak, QP=Quasi-peak, Av=Average

(1) Restricted bands of operation in 15.205

(1) Restricted bands of operation as defined in Table 6 of RSS-Gen

(2) The peak level is lower than the average limit (54 dBμV/m)

Sample N° 1 Central Channel (F = 2439.5 MHz)

Frequencies (MHz)	Detector P QP Av	Antenna height (cm)	RBW (kHz)	Position	Polarization H: Horizontal V: Vertical	Field strength Measured at 3 m (dBμV/m)	Limits (dBμV/m) or (dBm)	Margin (dB)
4879 (1)	P	150	1000	1	H	48.8 (2)	74	25.2
7218.5 (1)	P	150	1000	1	H	58.1	74	15.9
7218.5 (1)	Av	150	1000	1	H	51.8	54	2.2
9758	P	150	100	1	H	53.2	85.2	32.0

P= Peak, QP=Quasi-peak, Av=Average

(1) Restricted bands of operation in 15.205

(1) Restricted bands of operation as defined in Table 6 of RSS-Gen

(2) The peak level is lower than the average limit (54 dBμV/m)

Sample N° 1 High Channel (F = 2478.5 MHz)

Frequencies (MHz)	Detector P QP Av	Antenna height (cm)	RBW (kHz)	Position	Polarization H: Horizontal V: Vertical	Field strength Measured at 3 m (dBμV/m)	Limits (dBμV/m) or (dBm)	Margin (dB)
4957 (1)	P	150	1000	1	H	52.0 (2)	74	22.0
7435.5 (1)	P	150	1000	1	H	55.4	74	18.6
7435.5 (1)	Av	150	1000	1	H	49.3	54	4.7
9914	P	150	100	1	H	52.8	85.2	32.4

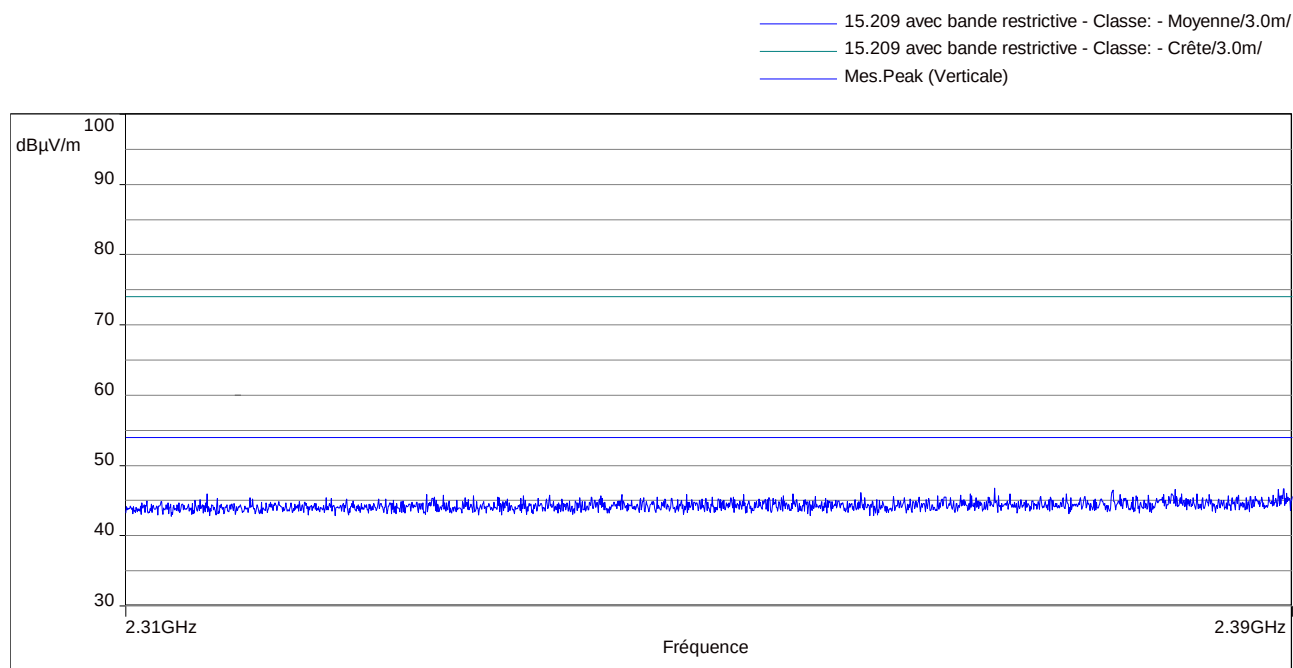
P= Peak, QP=Quasi-peak, Av=Average

(1) Restricted bands of operation in 15.205

(1) Restricted bands of operation as defined in Table 6 of RSS-Gen

(2) The peak level is lower than the average limit (54 dBμV/m)

Band edge worst case measurement (band 2.31GHz to 2.39GHz)



Applicable limits: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

The highest level recorded in a 100 kHz bandwidth is 105.2 dBμV/m on central channel.
 So the applicable limit is 85.2 dBμV/m.

In addition, radiated emissions which fall in the restricted band, as defined in section 15.205 (a), must also comply with the radiated emission limits specified in section 15.209 (a) (see section 15.205 (c)).

In addition, radiated emissions which fall in the restricted band, as defined in Table 6 of RSS-Gen, must also comply with the radiated emission limits specified in Table 4 and Table 5 of RSS-Gen.

Results:

Results: LoRa Modulation

Sample N° 1 Low Channel (F = 2402.5 MHz)

Frequencies (MHz)	Detector P QP Av	Antenna height (cm)	RBW (kHz)	Position	Polarization H: Horizontal V: Vertical	Field strength Measured at 3 m (dBμV/m)	Limits (dBμV/m) or (dBm)	Margin (dB)
4805 (1)	P	150	1000	1	H	47.4 (2)	74	26.6
7207.5	P	150	100	1	H	59.2	86	26.8
9610	P	150	100	1	H	54.6	86	31.4

P= Peak, QP=Quasi-peak, Av=Average

(1) Restricted bands of operation in 15.205

(1) Restricted bands of operation as defined in Table 6 of RSS-Gen

(2) The peak level is lower than the average limit (54 dBμV/m)

Sample N° 1 Central Channel (F = 2439.5 MHz)

Frequencies (MHz)	Detector P QP Av	Antenna height (cm)	RBW (kHz)	Position	Polarization H: Horizontal V: Vertical	Field strength Measured at 3 m (dBμV/m)	Limits (dBμV/m) or (dBm)	Margin (dB)
4879 (1)	P	150	1000	1	H	48.9 (2)	74	25.1
7218.5 (1)	P	150	1000	1	H	57.4	74	16.6
7218.5 (1)	Av	150	1000	1	H	54	54	0
9758	P	150	100	1	H	53.6	86	32.4

P= Peak, QP=Quasi-peak, Av=Average

(1) Restricted bands of operation in 15.205

(1) Restricted bands of operation as defined in Table 6 of RSS-Gen

(2) The peak level is lower than the average limit (54 dBμV/m)

Sample N° 1 High Channel (F = 2478.5 MHz)

Frequencies (MHz)	Detector P QP Av	Antenna height (cm)	RBW (kHz)	Position	Polarization H: Horizontal V: Vertical	Field strength Measured at 3 m (dBμV/m)	Limits (dBμV/m) or (dBm)	Margin (dB)
4957 (1)	P	150	1000	1	H	48.7 (2)	74	25.3
7435.5 (1)	P	150	1000	1	H	56.3	74	17.7
7435.5 (1)	Av	150	1000	1	H	52.9	54	1.1
9914	P	150	100	1	H	52.7	86	33.3

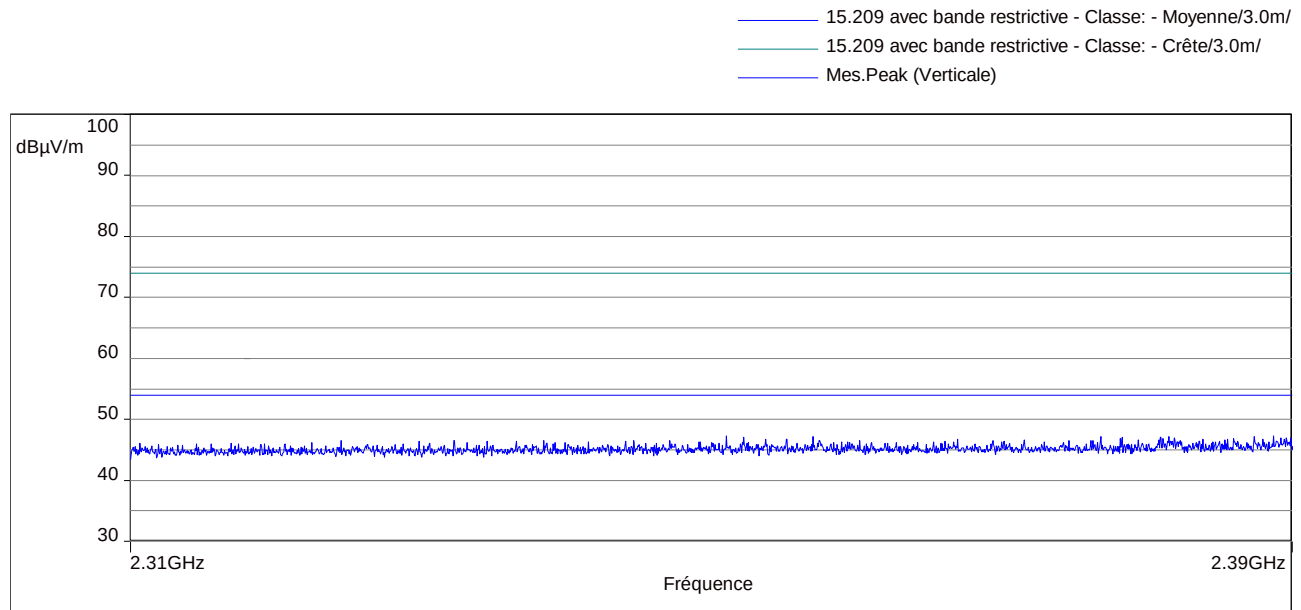
P= Peak, QP=Quasi-peak, Av=Average

(1) Restricted bands of operation in 15.205

(1) Restricted bands of operation as defined in Table 6 of RSS-Gen

(2) The peak level is lower than the average limit (54 dBμV/m)

Band edge worst case measurement (band 2.31GHz to 2.39GHz)



Applicable limits: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

The highest level recorded in a 100 kHz bandwidth is 106 dBμV/m on central channel.

So the applicable limit is 86 dBμV/m.

In addition, radiated emissions which fall in the restricted band, as defined in section 15.205 (a), must also comply with the radiated emission limits specified in section 15.209 (a) (see section 15.205 (c)).

In addition, radiated emissions which fall in the restricted band, as defined in Table 6 of RSS-Gen, must also comply with the radiated emission limits specified in Table 4 and Table 5 of RSS-Gen.

Test conclusion:

RESPECTED STANDARD

12. PEAK CONDUCTED POWER SPECTRAL DENSITY**Temperature (°C) :** 21.3**Humidity (%HR):** 48**Date :** November 3, 2020**Technician :** S. LOUIS**Standard:** FCC Part 15
RSS-247**Test procedure:**

For FCC Part 15: paragraph 15.247 (e), paragraph 15.247 (f)

For RSS-247: paragraph 5.2

PKPSD (Peak PSD) method of paragraph 11.10.2 of ANSI C63.10

Test set up:

First an exploratory radiated measurement was performed.

During this phase the product is oriented in these two normal positions.

Then the final measurement is realized with the product on the most critical orientation.

The system is tested in anechoic chamber, the EUT is placed on a rotating table, 1.5 m from a ground plane.

Zero degree azimuths correspond to the front of the device under test.

See photos in appendix 2.

Distance of antenna: 3 meters**Antenna height:** 1.5 meter**Antenna polarization:** vertical and horizontal (only the highest level is recorded)

The measurement of the radiated electro-magnetic field is realized with an analyser.

Span: 2MHz (for GFSK) / 1MHz (for LoRa)

Resolution bandwidth: 3kHz

Video bandwidth: 10kHz

Detector: Peak

Number of points: Auto

Sweep time: Auto

Trace mode: MaxHold

Then the peak marker function is used.

Finally the radiated electro-magnetic field is converted in dBm with the following formula:

$$EIRP(dBm) = E (dB\mu V/m) + 20\log(D) - 104.8; \text{ where } D \text{ is the measurement distance in meters and antenna Gain} = 2 \text{ dBi.}$$

Equipment under test operating condition:

The equipment is blocked in continuous modulated transmission mode by an internal data signal at the highest power level at which the transmitter is intended to operate.

P Software adjusted to +7dBm

We used for power source the internal battery of the equipment and we noted:

Voltage at the beginning of test (Vdc): 4.06

Voltage at the end of test (Vdc): 4.04

Percentage of voltage drop during the test (%): 0.5

Limits (%): ± 5

Results: GFSK Modulation

Sample N° 1: Low Channel (F = 2402.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted power density (dBm / 3 kHz)	Limit (dBm / 3 kHz)
Nominal supply voltage: 3.6V	93.6	-3.63	8

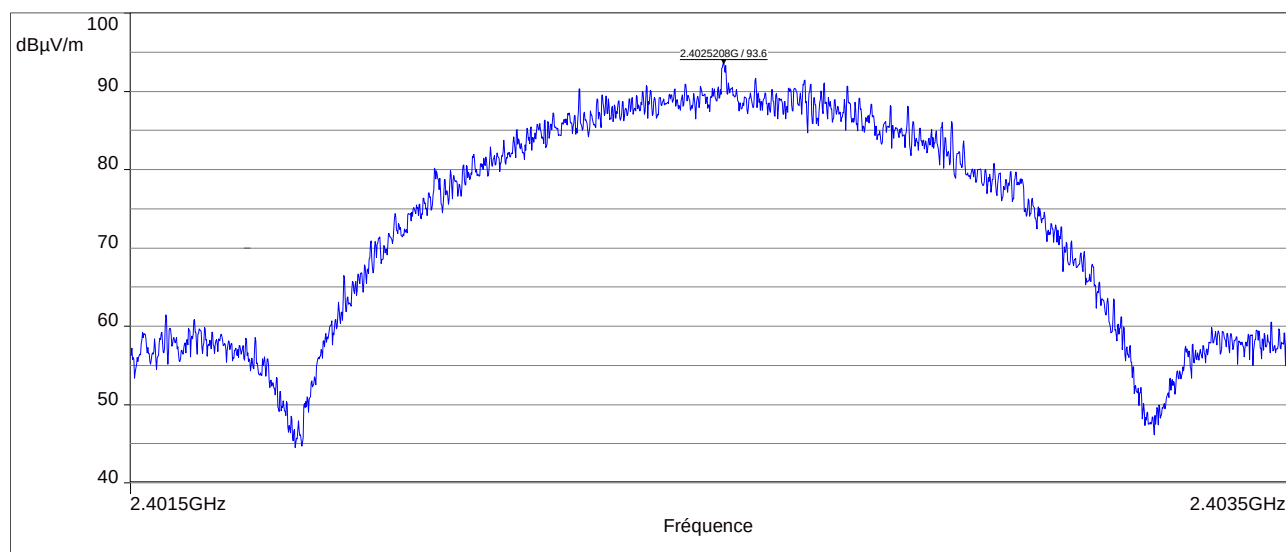
Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Maximum Peak conducted power density:

$EIRP(dBm / 3 kHz) = E (dBμV/m / 3 kHz) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 2 dBi.

Declared maximum antenna gain: 2 dBi



2.4025208G, 93.6 dBμV/m :

Sample N° 1: Central Channel (F = 2439.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted power density (dBm / 3 kHz)	Limit (dBm / 3 kHz)
Nominal supply voltage: 3.6V	94.5	-2.73	8

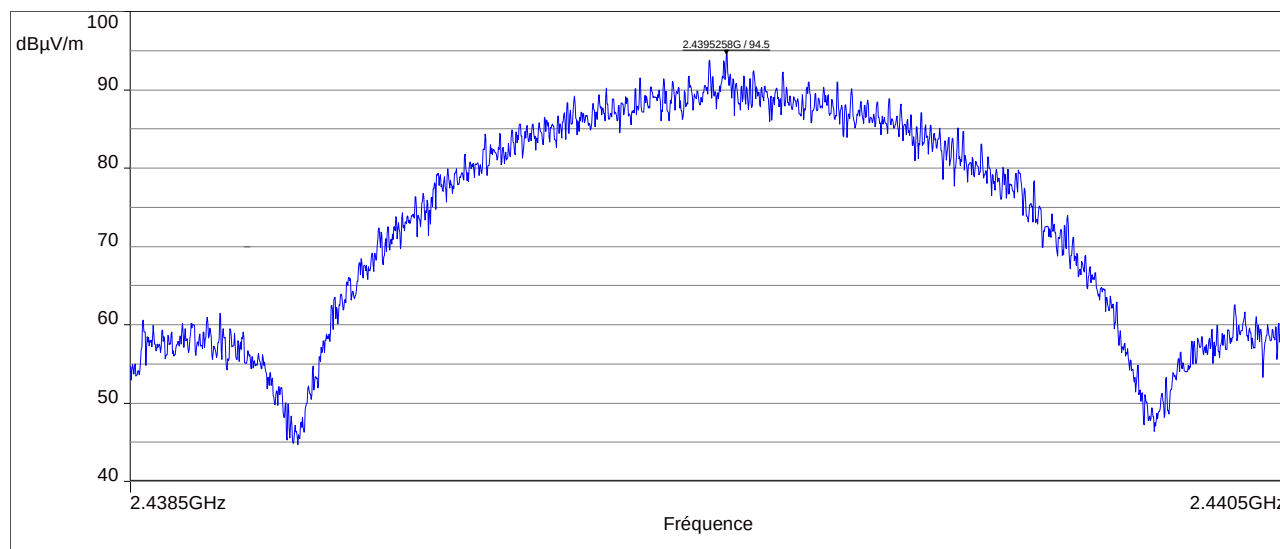
Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Maximum Peak conducted power density:

$EIRP(dBm / 3 kHz) = E (dBμV/m / 3 kHz) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 2 dBi.

Declared maximum antenna gain: 2 dBi



2.4395258G, 94.5 dBμV/m :

Sample N° 1: High Channel (F = 2478.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted power density (dBm / 3 kHz)	Limit (dBm / 3 kHz)
Nominal supply voltage: 3.6V	94.0	-3.23	8

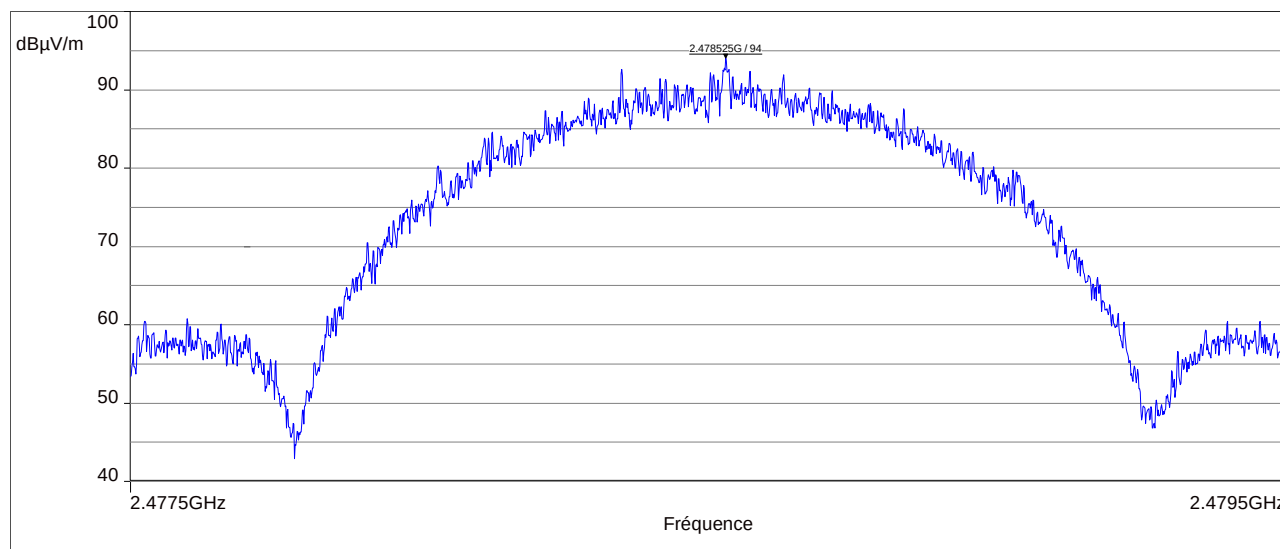
Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Maximum Peak conducted power density:

$EIRP(dBm / 3 kHz) = E (dBμV/m / 3 kHz) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 2 dBi.

Declared maximum antenna gain: 2 dBi



2.478525G, 94 dBμV/m :

Results: LoRa Modulation

Sample N° 1: Low Channel (F = 2402.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted power density (dBm / 3 kHz)	Limit (dBm / 3 kHz)
Nominal supply voltage: 3.6V	93.1	-4.13	8

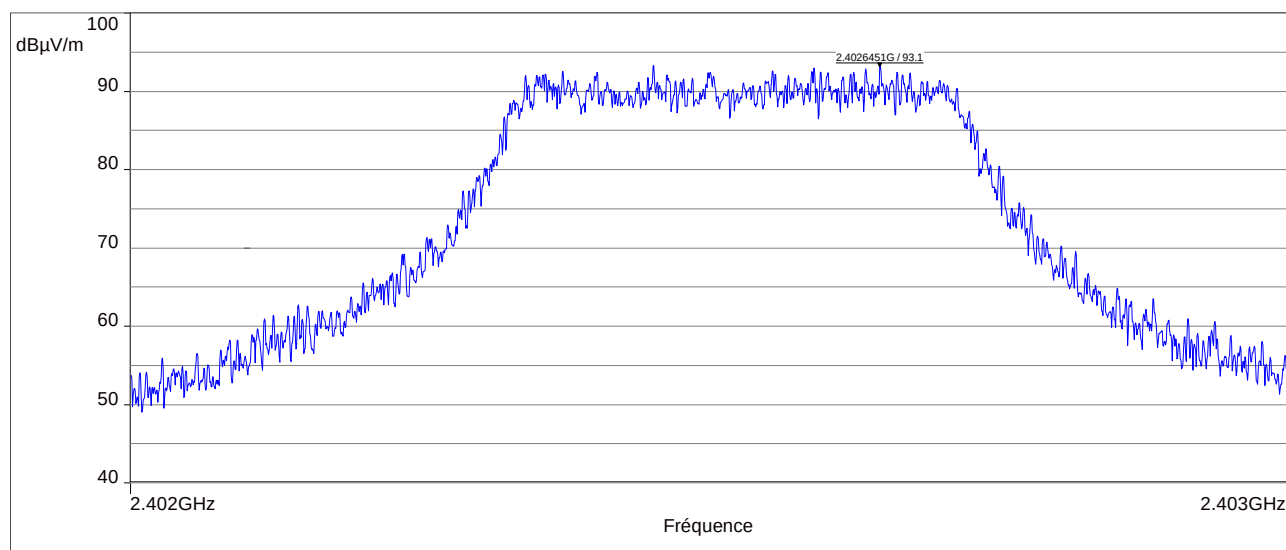
Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Maximum Peak conducted power density:

$EIRP(dBm / 3 kHz) = E (dBμV/m / 3 kHz) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 2 dBi.

Declared maximum antenna gain: 2 dBi



2.4026451G, 93.1 dBμV/m :

Sample N° 1: Central Channel (F = 2439.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted power density (dBm / 3 kHz)	Limit (dBm / 3 kHz)
Nominal supply voltage: 3.6V	95.1	-2.13	8

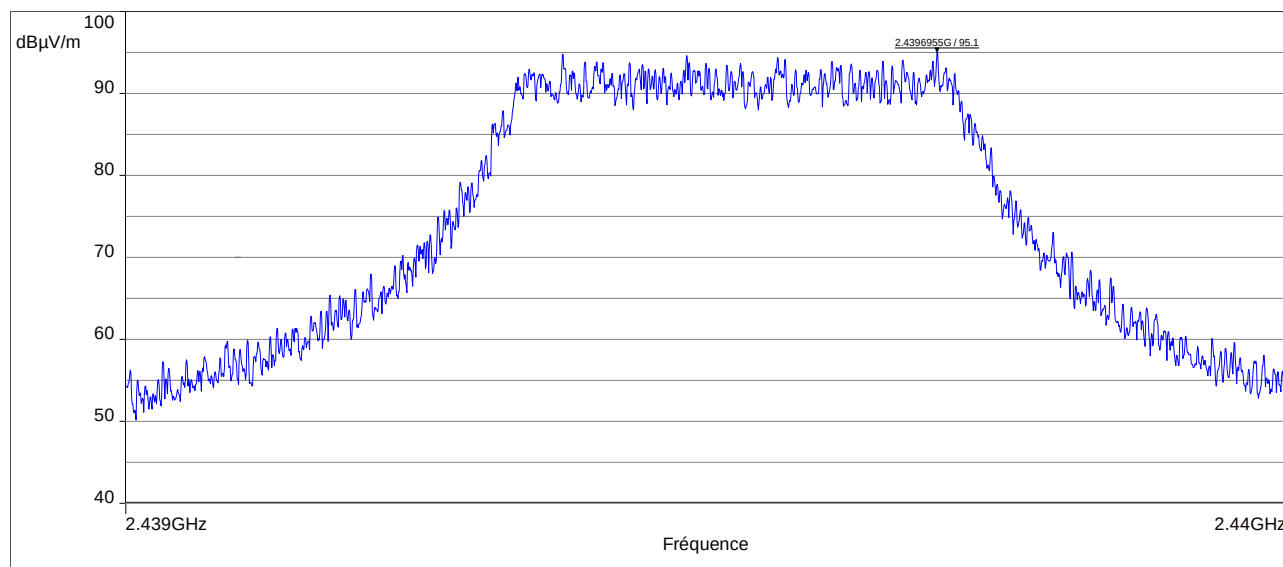
Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Maximum Peak conducted power density:

$EIRP(dBm / 3 kHz) = E (dBμV/m / 3 kHz) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 2 dBi.

Declared maximum antenna gain: 2 dBi



2.4396955G, 95.1 dBμV/m :

Sample N° 1: High Channel (F = 2478.5 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted power density (dBm / 3 kHz)	Limit (dBm / 3 kHz)
Nominal supply voltage: 3.6V	93.4	-3.83	8

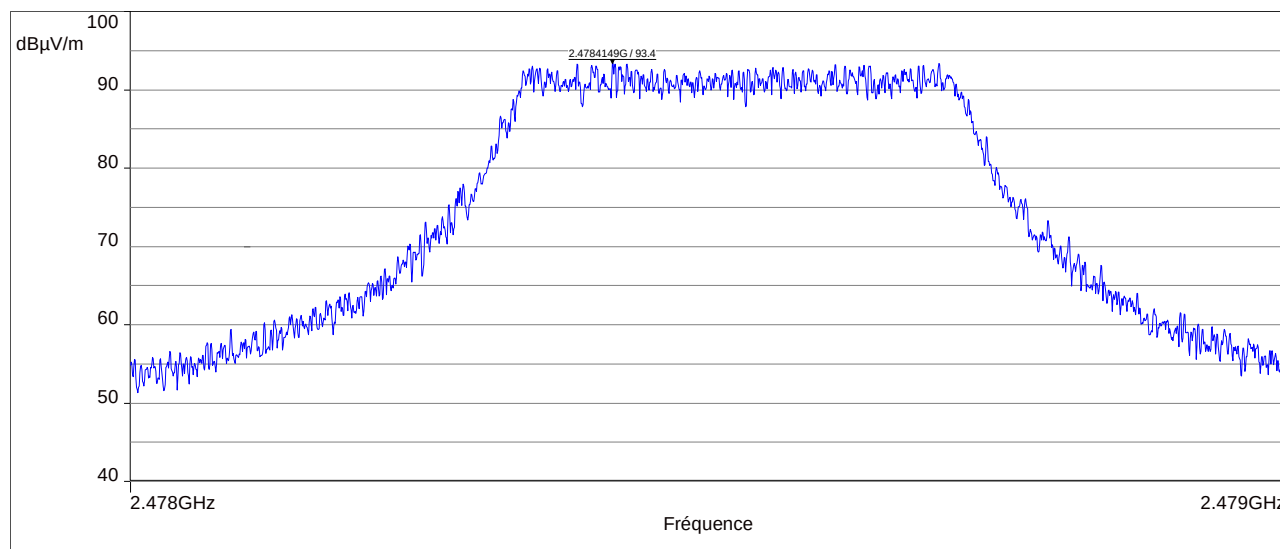
Polarization of test antenna: horizontal (height: 150 cm)

Position of equipment: Position 1 - (azimuth: 315 degrees)

Maximum Peak conducted power density:

$EIRP(dBm / 3 kHz) = E (dBμV/m / 3 kHz) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 2 dBi.

Declared maximum antenna gain: 2 dBi



2.4784149G, 93.4 dBμV/m :

Test conclusion:

RESPECTED STANDARD

□□□ End of report, 1 appendix to be forwarded □□□

APPENDIX 1: Test equipment list

Occupied bandwidth

TYPE	MANUFACTURER	EMITECH NUMBER
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Antenna 3115	EMCO	8535
N-2M Cable	Huber + Suhner	12911
N-5M Cable	SUCOFLEX	15882
Multimeter 177	Fluke	14831
Meteo station WS-9232	La Crosse Technology	8750
Software	GPIBSHOT V2.4	-

Band edge

TYPE	MANUFACTURER	EMITECH NUMBER
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Antenna 3115	EMCO	8535
N-2M Cable	Huber + Suhner	12911
N-5M Cable	SUCOFLEX	15882
Multimeter 177	Fluke	14831
Meteo station WS-9232	La Crosse Technology	8750
Software	GPIBSHOT V2.4	-

Peak conducted output power

TYPE	MANUFACTURER	EMITECH NUMBER
Anechoic Chamber	EMITECH	8593
Turntable controller 1060C	MATURO	14736
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Antenna 3115	EMCO	8535
N-2M Cable	Huber + Suhner	12911
N-5M Cable	SUCOFLEX	15882
Multimeter 177	Fluke	14831
Meteo station WS-9232	La Crosse Technology	8750
Software	BAT-EMC V3.18.0.26	0000

Radiated spurious emissions

TYPE	MANUFACTURER	EMITECH NUMBER
Anechoic Chamber	EMITECH	8593
Turntable controller 1060C	MATURO	14736
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Loop antenna 6502	EMCO	1406
Biconical antenna VHBB 9124	Schwarzbeck	8526
Log periodic antenna UHALP 9108A	Schwarzbeck	8543
Antenna 3115	EMCO	8535
Antenna SAS-572	A.H Systems	7124
Antenna SAS-572	A.H Systems	7125
Low-noise amplifier 8447D	Hewlett Packard	8511
Low-noise amplifier PAM-118A	COM-POWER	15812
Low-noise amplifier S180265L3201	LUCIX Corp.	8704
N-1.5M Cable	SUCOFLEX	7279
N-2M Cable	Huber + Suhner	12911
N-5M Cable	SUCOFLEX	15882
Cable k-20cm	STORM MICROWAE	8974
Cable k-20cm	STORM MICROWAE	8975
Low pass filter LP03/1000-7GH	Filtek	4087
Reject band filter BRM50702	Microtronics	7299
Multimeter 177	Fluke	14831
Meteo station WS-9232	La Crosse Technology	8750
Software	BAT-EMC V3.18.0.26	0000

Peak conducted power spectral density

TYPE	MANUFACTURER	EMITECH NUMBER
Anechoic Chamber	EMITECH	8593
Turntable controller 1060C	MATURO	14736
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Loop antenna 6502	EMCO	1406
Biconical antenna VHBB 9124	Schwarzbeck	8526
Log periodic antenna UHALP 9108A	Schwarzbeck	8543
Antenna 3115	EMCO	8535
Antenna SAS-572	A.H Systems	7124
Antenna SAS-572	A.H Systems	7125
Low-noise amplifier 8447D	Hewlett Packard	8511
Low-noise amplifier PAM-118A	COM-POWER	15812
Low-noise amplifier S180265L3201	LUCIX Corp.	8704
N-1.5M Cable	SUCOFLEX	7279
N-2M Cable	Huber + Suhner	12911
N-5M Cable	SUCOFLEX	15882
Cable k-20cm	STORM MICROWAE	8974
Cable k-20cm	STORM MICROWAE	8975
Low pass filter LP03/1000-7GH	Filtek	4087
Reject band filter BRM50702	Microtronics	7299
Multimeter 177	Fluke	14831
Meteo station WS-9232	La Crosse Technology	8750
Software	BAT-EMC V3.18.0.26	0000